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Effect of Vitamins on Concentration of Blood Serum Components and Amino Acids

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Summary

Effects of different vitamins on concentration of blood serum components and amino acid were studied, using male rats of the Wister strain. Five kinds of vitamins, namely vitamin A, v. B_1 (thiamin), v. C (ascorbic acid), v. D (calciferol), v. E (tocopherol) were used in this study. They were injected subcutaneously in a single dose of 500 IU, 2.5 mg, 2.5 mg, 1000 IU and 2.5 mg, respectively.

The animals were sacrificed by decapitating at four hours following the injection. Blood sample taken at the time of sacrifice was centrifuged for separation of serum after 10 hours-standing at room temperature. The serum was determined for concentration of its components, using Vet-Aid described previously[5] and analyzed for amino acids, using a full automatic amino acid analyzer previously described[5].

Concentration of cholesterol in the serum was elevated by the administration of vitamins A, B and C, and it was lowered significantly by the administration of vitamins D and E. These vitamins seemed to have a close relation to fat deposition in the meat. The effect of vitamins on fat deposition in beef would require further study.

Introduction

Vitamins play important roles in metabolism of animals. Deficiency or excessive of vitamin causes a decline of growth and various metabolic diseases. Vitamins will presumably influence on the quality of meat through change of metabolism and fat deposition. Vitamins are very important nutrients in actual feeding and management of cattle. So, changes of concentration of blood components and free amino acid in blood serum following administration of vitamin are expected. There is, however, scant available report in this field.

This study was designed to elucidate the effects of vitamins on concentration of blood serum components and phenomena seemed to relate to fat deposition.

Materials and Methods

Thirty-one male rats of the Wister strain, weighing 161 to 200 g, were used in this study.

Vitamins were injected to rats singly subcutaneously. Dose of vitamin A was 500 IU, vitamin B_1 2.5 mg, vitamin C 2.5 mg, vitamin D 1000 IU and vitamin E 2.5 mg.

Rats were killed by decapitating at four hours following the injection of vitamin. The blood was kept at room temperature for about 10 hours, and centrifuged for separation of serum.

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The serum of each animal was divided to two portions. One portion was used for determination of concentration of its components, and another portion was used for analysis of free amino acid composition, using full automatic amino acid analyzer[5].

Results and Discussion

Results are shown in Table 1 to Table 4. It has been known that metabolic activity in the tissue is high when concentration of magnesium in the serum is low, and converse is true also. Magnesium requirement in the tissue is increased when metabolic activity in the tissue is high. Judging from the point of view of concentration of serum magnesium, vitamins tested seemed to increase the metabolic activity of the tissue. Particularly, vitamins C and E significantly stimulate the metabolism in tissue. Vitamin A accelerates metabolism as above mentioned. Administration of vitamin A decreased concentration of serum components. This may be due to the accelerated metabolism and suggests a consumption of serum component. There was a tendency to rise the level of cholesterol. This coincides with the report showing accelerative effect of vitamin A on metabolism, which showed that administration of vitamin A in a large dose, an excessive amount, caused first rise of level of concentration of serum cholesterol and soluble phospholipids and then their decrease. Administration of vitamin A in the period of finishing of beef cattle may be unfavourable to fat deposition. Vitamin A seems disturb the deposition of fat in meat.

Table 1. Effects of vitamins on concentration of blood serum components at 4 hours following the injection

Item	Control	4 hrs				
		Vit. A	Vit. B_1	Vit. C	Vit. D	Vit. E
No. of rats	6	5	5	5	5	5
Body wt., g	164±33	200±46	189±37	209±22	170±33	161±29
TP, g/dl	7.8±1.6	7.5±2.6	7.2±1.7	8.7±2.9	9.5±2.2	6.5±2.9
Alb, g/dl	2.3±0.4	1.9±0.5	2.0±0.4	2.1±0.7	1.9±0.6	1.6±0.5
Gl, g/dl	5.5±1.2	5.6±2.2	5.2±1.7	6.7±2.7	7.5±1.8	4.9±2.5
BUN, mg/dl	8.6±2.1	7.1±1.7	8.3±1.1	11.8±3.1	13.7±2.9*	10.2±3.5
Chol, mg/dl	83±13	98±14	105±28	114±31	26±19**	24±14**
Ca, mg/dl	10.4±0.9	8.5±2.4	8.3±1.3*	10.1±2.7	7.5±1.3**	6.0±2.2**
P, mg/dl	7.6±1.0	6.3±1.5	7.4±0.6	8.6±1.8	6.8±1.4	5.5±2.3
Mg, mg/dl	4.7±1.5	3.6±0.7	3.6±1.3	2.0±0.9*	2.9±1.2	2.3±1.2*

* $P < 0.05$ Significantly different to control.
** $P < 0.01$ Significantly different to control.

Table 2. Effects of vitamins on concentration of blood serum components

Item	Control	8 hrs				
		Vit. A	Vit. B_1	Vit. C	Vit. D	Vit. E
No. of rats	6	5	5	5	5	5
Body wt., g	164±33	174±10	173±23	209±51	166±16	174±20
TP, g/dl	7.8±1.6	9.3±2.2	7.6±1.7	5.1±0.7*	5.7±0.5*	5.1±1.0*
Alb, g/dl	2.3±0.4	2.1±0.4	1.9±0.4	2.1±0.4	2.4±0.4	2.0±0.3
Gl, g/dl	5.5±1.2	7.2±2.2	5.7±1.4	3.0±0.3	3.3±0.3	3.1±1.0
BUN, mg/dl	8.6±2.1	9.7±1.6	9.3±1.2	10.9±2.3	10.6±1.3	10.4±2.9
Chol, mg/dl	83±13	65±16	30±10**	108±11*	125±60	75±9
Ca, mg/dl	10.4±0.9	8.0±2.0	7.8±2.3	10.1±1.7	10.0±2.6	8.1±3.4
P, mg/dl	7.6±1.0	10.2±1.8*	8.8±1.9	7.7±1.3	8.5±0.9	7.9±1.2
Mg, mg/dl	4.7±1.5	2.3±0.9*	2.4±1.2*	4.3±1.2	4.2±1.3	1.7±0.8**

* $P < 0.05$ Significantly different to control.
** $P < 0.01$ Significantly different to control.

Table 3. Effect of vitamins on concentration of free amino acid of blood serum in rats at 4 hours following the injection

	Control	Vit. A inj.	Vit. B_1 inj.	Vit. C inj.	Vit. D inj.	Vit. E inj.
Tau	0.324±0.014 (7.43)	0.361±0.090 (7.79)	0.490±0.096* (8.93)	0.423±0.038* (7.52)	0.374±0.073 (7.44)	0.270±0.053 (7.26)
Asp-n	0.097±0.011 (2.23)	0.108±0.033 (2.33)	0.123±0.013* (2.24)	0.103±0.014 (1.83)	0.100±0.016 (1.99)	0.075±0.023 (2.02)
Hypro	0.037±0.010 (0.85)	0.027±0.012 (0.58)	0.024±0.008 (0.44)	0.033±0.008 (0.59)	0.037±0.012 (0.74)	0.019±0.005* (0.51)
Thr	0.305±0.037 (7.00)	0.308±0.078 (6.65)	0.372±0.077 (6.78)	0.370±0.011* (6.57)	0.342±0.073 (6.80)	0.296±0.099 (7.96)
Ser	0.315±0.042 (7.23)	0.369±0.080 (7.96)	0.423±0.074 (7.71)	0.383±0.047 (6.81)	0.384±0.085 (7.64)	0.297±0.067 (7.99)
Asp-n	0.091±0.009 (2.09)	0.078±0.022 (1.68)	0.116±0.022 (2.11)	0.128±0.021* (2.27)	0.122±0.056 (2.43)	0.082±0.028 (2.20)
Glu. A	0.450±0.079 (10.32)	0.459±0.113 (9.90)	0.544±0.069 (9.92)	0.585±0.005* (10.39)	0.439±0.087 (8.73)	0.343±0.069 (9.22)
Glu-n	0.273±0.031 (6.26)	0.284±0.021 (6.13)	0.338±0.114 (6.16)	0.303±0.062 (5.38)	0.272±0.103 (5.41)	0.191±0.080 (5.14)
Pro	0.166±0.025 (3.81)	0.127±0.042 (2.74)	0.155±0.035 (2.83)	0.231±0.055 (4.10)	0.202±0.090 (4.02)	0.150±0.055 (4.03)
Gly	0.386±0.002 (8.85)	0.441±0.081 (9.51)	0.512±0.113 (9.33)	0.464±0.055 (8.24)	0.387±0.074 (7.70)	0.311±0.070 (8.36)
Ala	0.542±0.036 (12.43)	0.491±0.132 (10.59)	0.593±0.097 (10.81)	0.698±0.050* (12.40)	0.643±0.184 (12.79)	0.451±0.100 (12.13)
Val	0.125±0.018 (2.87)	0.158±0.044 (3.41)	0.174±0.025* (3.17)	0.181±0.023* (3.22)	0.164±0.056 (3.26)	0.119±0.018 (3.20)
Met	0.055±0.012 (1.26)	0.045±0.016 (0.97)	0.066±0.011* (1.20)	0.082±0.006* (1.46)	0.076±0.035 (1.51)	0.046±0.012 (1.24)
Ileu	0.097±0.012 (2.23)	0.118±0.034 (2.55)	0.124±0.011* (2.26)	0.117±0.012* (2.08)	0.103±0.022 (2.05)	0.083±0.020 (2.23)
Leu	0.147±0.013 (3.37)	0.164±0.048 (3.54)	0.187±0.021 (3.41)	0.192±0.022 (3.41)	0.167±0.039 (3.32)	0.136±0.028 (3.66)
Tyr	0.069±0.018 (1.58)	0.069±0.018 (1.49)	0.071±0.007 (1.29)	0.080±0.007 (1.42)	0.079±0.023 (1.57)	0.056±0.016 (1.51)
Phe	0.067±0.005 (1.54)	0.077±0.028 (1.66)	0.087±0.009* (1.59)	0.094±0.015* (1.67)	0.082±0.027 (1.63)	0.055±0.013 (1.48)
Orn	0.080±0.014 (1.84)	0.074±0.022 (1.60)	0.093±0.011 (1.70)	0.136±0.038 (2.42)	0.106±0.052 (2.11)	0.083±0.013 (2.23)
Lys	0.521±0.119 (11.95)	0.504±0.146 (10.87)	0.593±0.080 (10.81)	0.621±0.088 (11.03)	0.560±0.146 (11.14)	0.379±0.090 (10.19)
l-M-His	0.037±0.0007 (0.85)	0.031±0.000 (0.67)	0.029±0.003* (0.53)	0.040±0.009 (0.71)	0.040±0.009 (0.80)	0.036±0.010 (0.97)
His	0.056±0.013 (1.28)	0.071±0.011 (1.53)	0.084±0.004* (1.53)	0.085±0.008* (1.51)	0.096±0.023 (1.91)	0.052±0.014 (1.40)
Arg	0.264±0.039 (6.06)	0.262±0.097 (5.65)	0.297±0.057 (5.41)	0.276±0.038 (4.90)	0.253±0.026 (5.03)	0.191±0.047 (5.14)
Total AA**	4.360±0.639 (100)	4.635±1.199 (100)	5.486±0.619 (100)	5.628±0.193* (100)	5.028±1.285 (100)	3.719±0.875 (100)

* $P < 0.05$ to the control.
** Except Urea and NH_3.
Sample size (N) = 4 rats.
( ) = percentage, %.

Vitamin A is effective in protein anabolism and huge amount of vitamin A is consumed up in accumulation of protein. Concentration of total amino acid was not changed by the administration of vitamin A.

Vitamin B_1 has an important role in conversion of carbohydrate to lipids and proteins[7,8]. Deficiency of vitamin B_1 causes a disturbance of carbohydrate metabolism and accelerate decomposition of amino acid histidine[6], and administration of the vitamin to normal rat causes a decrease of excretion of histidine in urine. In the present study, the injection of vitamin B_1

increased concentration of cholesterol and of most amino acid. This suggests that vitamin B_1 is favorable to fat deposition and growth of cattle. Thus, good ruminal fermentation producing vitamin B_1 is desirable to fattening cattle.

Vitamin C enhances action of protease [2, 15, 17], and the vitamin activates also deaminase of histidine [11]. Vitamin C has an antagonistic action to function of the thyroid gland [9, 14, 16], and inhibit carbohydrase [12], and has an synergistic action to function of the adrenals [2, 13]. In the present fact that glucocorticoid being a hormone secreted from the cortical tissue of adrenal enhances the action of neoglycogenesis. A tendency of positive correlation between fat deposit in the eye-muscle and concentration of cholesterol in the serum of cattle has been reported previously [5]. Effects of vitamin C seemed favourable to fat deposition in meat.

Vitamin D has an important role in absorption of calcium and in less extent magnesium. The protein binding to Ca is necessary for absorption of calcium through the wall of intestine. The protein binding to Ca is synthesized by effect of vitamin D. Concentration of calcium in the serum decreased by the administration of vitamin D. This may be due to effect of vitamin D in incorporating calcium to hard tissue.

Levels of most amino acid in serum were risen up by the effect of vitamin D, and level of cholesterol was lowered significantly. So, vitamin D has an effect relating to fat deposition and seemed not favourable to fat deposition, within the dose used. Concerning this point, further study would be required.

Table 4. Comparison of effect of vitamins on amino acid concentration of blood serum in rats at 4 hrs. after injection

A. A.	Control	Vit. A inj.	Vit. B_1 inj.	Vit. C inj.	Vit. D inj.	Vit. E inj.
Tau	100	111.4*	151.2*	130.5*	115.4*	83.3*
Asp. A	100	111.3	126.8	106.2	103.0	77.3
Hypro	100	72.9	64.9	89.2	100.0	51.4
Thr	100	109.8	121.9	121.3	112.1	97.0
Ser	100	117.1	134.3	121.6	121.9	94.3
Asp-n	100	85.7	127.5	140.7	134.1	90.1
Glu. A	100	102.0	120.9	130.0	97.6	76.2
Glu-n	100	104.0	123.8	111.0	99.6	69.9
Pro	100	76.5	93.4	139.2	121.7	90.4
Gly	100	114.2	132.6	120.2	100.3	80.6
Ala	100	90.6	109.4	128.8	118.6	83.2
Val	100	126.4	139.2	144.8	131.2	95.2
Met	100	81.8	146.7	149.1	138.2	83.6
Ileu	100	121.6	127.8	120.6	106.2	85.6
Leu	100	111.6	127.2	130.6	113.6	92.5
Tyr	100	100.0	102.9	115.9	114.5	81.2
Phe	100	114.9	129.9	140.3	122.4	82.1
Orn	100	92.5	116.3	170.0	132.5	103.8
Lys	100	96.7	113.8	119.2	107.5	72.7
1-M-His	100	83.8	78.4	108.1	108.1	97.3
His	100	126.8	150.0	151.8	171.4	92.9
Arg	100	99.2	112.5	104.5	95.8	72.3
Total AA	100	106.3	125.8	129.1	115.3	85.3

* Ratio to the control in percentage.

Vitamin E is an antioxydant substance and necessary to the thyroidal function [1]. Deficiency of vitamin E causes a metabolic and cellular change similar to that of castration in rats [3, 4, 10, 17]. In the present study, vitamin E caused decreases of concentration of amino acids and blood component. Vitamin E also seemed not favourable to fat deposition.

Conclusively, vitamin B_1 and C seemed favourable to fat deposition in the meat, but vitamin D and E seemed not favourable.

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血清の成分およびアミノ酸の濃度に対するビタミンの効果

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血液の成分およびアミノ酸に対する種々のビタミンの効果をウイスター系ラッテを用いて研究した．

ビタミンとしてはビタミン A，B，C，D，E を用い，それぞれ500 IU，2.5 mg，2.5 mg，1000 IU および 2.5 mg を 1 回，皮下注射をした．注射後 4 時間に供試動物を断頭によって採血し，室温に 10 時間静置後，遠心分離によって血清を採った．これら血清の成分の濃度は Vet-Aid により，またアミノ酸の濃度は既述の全自動アミノ酸分析機を用いて測定した．

血清コレステロールの濃度はビタミン A，B_1 および C の注射によって増加し，ビタミン D または E の注射によって有意に低下した．これらのビタミンは肉の脂肪交雑に密接な関係を有するものと考えられる．牛肉の脂肪交雑に対するビタミンの効果に関しては今後の研究を要する．

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